THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

DIPLOMA IN SECONDARY EDUCATION EXAMINATION

732/1 **CHEMISTRY 1**

Time: 3 Hours **ANSWERS** **Year: 2013**

Instructions

1. This paper consists of section A, B and C.

2. Answer all questions in section A and two questions from section B and C.

SECTION A (40 Marks)

Answer all questions in this section.

1. Give the meaning of the following terms:

(a) Principal quantum number: The principal quantum number (n) indicates the energy level or shell of an electron in an atom, determining its distance from the nucleus, critical for understanding atomic structure.

(b) Electromagnetic spectrum: The electromagnetic spectrum is the range of all possible frequencies of electromagnetic radiation, such as radio waves to gamma rays, essential for studying wave properties.

(c) Ionic bonding: Ionic bonding is the electrostatic attraction between oppositely charged ions, like Na^+ and Cl^- in sodium chloride, key for explaining chemical compound formation.

2. Outline three advantages of making analysis of test results

Identifies Weaknesses: Reveals areas of poor performance, like low scores in reactions, aiding targeted improvement in chemical understanding.

Measures Progress: Tracks skill development, such as improved titration accuracy, providing evidence of chemical mastery.

Guides Instruction: Suggests focus areas, like emphasizing stoichiometry, enhancing effectiveness of chemical education.

3. (a) Define standard enthalpy of formation

Standard enthalpy of formation (ΔH_f°) is the change in enthalpy when one mole of a compound is formed from its elements in their standard states under standard conditions (1 atm, 25°C), crucial for thermochemical calculations.

3. (b) Find the enthalpy of reaction between NH_3 and HCl represented by the reaction equation:

$NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$

Given that the standard enthalpies of formation of the respective compounds are:

NH_3 = -46 kJ/mol, HCl = -92.3 kJ/mol and NH_4Cl = -315 kJ/mol

$\Delta H_{reaction} = \Sigma \Delta H_f^\circ(products) - \Sigma \Delta H_f^\circ(reactants)$

$= \Delta H_f^\circ(NH_4Cl) - [\Delta H_f^\circ(NH_3) + \Delta H_f^\circ(HCl)]$

$= -315 - [(-46) + (-92.3)] = -315 - (-138.3) = -315 + 138.3 = -176.7$ kJ/mol

Essential for understanding chemical reaction energetics and thermochemistry.

4. Briefly explain three functions of a Chemistry logbook

Records Experiments: Documents procedures, like titration steps, preserving details of chemical activities for reference.

Tracks Observations: Notes results, such as color changes in reactions, aiding analysis of chemical phenomena.

Ensures Accuracy: Verifies data, like pH measurements, maintaining reliability in chemical records.

5. (a) Give the meaning of 'isomerism'

Isomerism is the phenomenon where compounds have the same molecular formula but different structural arrangements, like butane and isobutane, critical for understanding chemical diversity.

5. (b) Write two isomers of chloroalkane with 5 carbon atoms ($C_5H_{11}Cl$)

1-Chloropentane: Cl attached to the first carbon, $CH_2Cl\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3$, a structural variant of chloroalkane.

2-Chloropentane: Cl attached to the second carbon, $CH_3\text{-}CHCl\text{-}CH_2\text{-}CH_2\text{-}CH_3$, another structural form of chloroalkane.

6. Why does each of the following not be used to prepare primary standard solution?

(a) Concentrated sulphuric acid: Its high purity is uncertain and it absorbs water, altering concentration, unsuitable for precise chemical standards.

(b) Concentrated hydrochloric acid: It is volatile and releases gas, causing concentration changes, unreliable for chemical standardization.

(c) Sodium hydroxide pellets: They are hygroscopic and impure, absorbing moisture and varying in mass, inappropriate for accurate chemical solutions.

7. List three factors that must be considered when preparing a scheme of work

Syllabus Coverage: Ensures all topics, like chemical bonding, are included, aligning with curriculum goals.

Time Allocation: Assigns duration, such as 10 hours for acids, optimizing schedule efficiency.

Resource Availability: Accounts for materials, like lab equipment, ensuring practical feasibility.

8. If you were to attract a Form I class to study Chemistry, explain three points to convince based on the importance of the subject in daily life

Everyday Applications: Chemistry explains cooking processes, like baking reactions, making it relevant to daily activities.

Health and Medicine: It underpins drug development, such as aspirin synthesis, crucial for health improvements.

Environmental Impact: Chemistry addresses pollution control, like acid rain neutralization, vital for ecological balance.

9. Outline six common sources of unexpected fire in the Chemistry Laboratory

Flammable Chemicals: Spills of ethanol near flames ignite easily, posing fire risks in labs.

Electrical Faults: Faulty wiring or overloaded circuits spark fires, a common laboratory hazard.

Open Flames: Unattended Bunsen burners cause accidental ignitions, increasing fire danger.

Chemical Reactions: Exothermic reactions, like magnesium burning, can escalate into fires.

Improper Storage: Storing oxidizers with fuels, such as near paper, triggers unexpected combustion.

Human Error: Mishandling, like spilling oil on a hot plate, leads to unintended fires in labs.

10. (a) With relevant examples, give the meaning of the term "ligand" as applied in coordination compounds

A ligand is a molecule or ion that donates a pair of electrons to a central metal ion to form a coordination compound, such as NH_3 in $[Cu(NH_3)_4]^{2+}$ or Cl^- in $[CoCl_4]^{2-}$, essential for understanding complex chemistry.

10. (b) With the aid of equation, explain why anhydrous blue cobalt (II) chloride turns pink when exposed to moisture

Reaction: $CoCl_2(s) + 6H_2O \rightarrow CoCl_2 \cdot 6H_2O(s)$

Anhydrous blue $CoCl_2$ absorbs water, forming pink $CoCl_2 \cdot 6H_2O$ due to hydration, changing its physical color and coordination structure, key for studying chemical hydration effects.

SECTION B (30 Marks)

Answer two (2) questions from this section.

11. (a) Briefly describe five components of soil

Mineral Matter: Inorganic components, like sand and clay, form the physical structure of soil, supporting plant growth.

Organic Matter: Decomposed plants and animals, such as humus, enrich soil fertility.

Water: Moisture holds nutrients, like dissolved ions, aiding chemical reactions in soil.

Air: Oxygen in pores supports root respiration, essential for soil health.

Living Organisms: Microbes and worms, like earthworms, enhance soil structure and nutrient cycling.

11. (b) The pH of a sample of sandy soil was dissolved in water for analysis. The sample solution was found to have OH^- concentration of 5×10^{-7}. Calculate the pH of the soil

$pOH = -\log[OH^-] = -\log(5 \times 10^{-7}) \approx 6.3$

$pH + pOH = 14$, so $pH = 14 - 6.3 = 7.7$

Critical for understanding soil chemistry and pH calculations based on ion concentrations.

12. (a) Briefly explain how each of the following physical changes occurs

(i) Melting: Transition from solid to liquid, like ice to water, occurs as heat increases molecular vibration, breaking the physical lattice structure.

(ii) Vaporization: Conversion from liquid to gas, such as water to steam, happens when heat overcomes intermolecular forces, allowing molecules to escape.

(iii) Condensation: Change from gas to liquid, like steam to water, occurs as cooling reduces molecular energy, enabling bonding.

12. (b) (i) State the first law of thermodynamics

The first law of thermodynamics states that the total energy of an isolated system is constant; energy can be transformed but not created or destroyed, fundamental for understanding energy conservation.

12. (b) (ii) Calculate the heat of formation of methane from the following data:

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ $\Delta H = -886$ kJ

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H = -407$ kJ

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ $\Delta H = -286$ kJ

$\Delta H_f^\circ(CH_4) = [\Delta H_f^\circ(CO_2) + 2\Delta H_f^\circ(H_2O)] - \Delta H_{reaction}$

From data: $\Delta H_f^\circ(CO_2) = -407$ kJ/mol, $\Delta H_f^\circ(H_2O) = -286$ kJ/mol

Heat of combustion $\Delta H = -886$ kJ for CH_4 formation reverse:

$\Delta H_f^\circ(CH_4) = [-407 + 2(-286)] - (-886) = [-407 - 572] + 886 = -979 + 886 = -93$ kJ/mol

Essential for calculating chemical energy changes and thermochemical properties.

12. (b) (iii) Giving reason, state whether the reaction is endothermic or exothermic

The reaction $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ with $\Delta H = -886$ kJ is exothermic, as heat is released (negative ΔH), indicating an energy decrease, critical for assessing reaction energetics.

13. (a) What do you understand by the term ‘soil fertility’?

Soil fertility is the ability of soil to provide essential nutrients, like nitrogen and phosphorus, and support plant growth, vital for agricultural chemistry and productivity.

13. (b) Explain five advantages of applying manures instead of synthetic fertilizers in the field

Improves Soil Structure: Manure, like compost, enhances soil texture, aiding root penetration and water retention.

Sustains Nutrient Release: Releases nutrients slowly, like organic nitrogen, avoiding chemical leaching compared to synthetic fertilizers.

Boosts Microbial Activity: Encourages beneficial microbes, like bacteria, improving soil health unlike synthetic alternatives.

Reduces Environmental Impact: Minimizes runoff pollution, such as nitrate leaching, compared to synthetic fertilizers' chemical residues.

Cost-Effective: Utilizes organic waste, like farmyard manure, reducing reliance on expensive synthetic inputs.

SECTION B (40 Marks)

Answer two (2) questions from this section.

14. (a) Give the meaning of the following terms as used in organic chemistry:

(i) Nucleophile: A nucleophile is a species rich in electrons, such as OH^-, that donates electrons to form a bond with an electron-deficient atom, critical for understanding organic reaction mechanisms.

(ii) Electrophile: An electrophile is a species that accepts electrons, like H^+, due to electron deficiency, essential for analyzing organic reactions and bond formation.

14. (b) In each of the following reactions, complete the equation and give the name of the major product only:

(i) $C_6H_5CH_3 + H_2SO_4 \rightarrow$

Equation: $C_6H_5CH_3 + H_2SO_4 \rightarrow C_6H_5SO_3H + CH_4$ (Sulphonation)

Major Product: Benzenesulphonic acid, key for understanding aromatic substitution reactions.

(ii) $CH_4 + Cl_2 \rightarrow$ (UV, controlled)

Equation: $CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$ (Free radical substitution)

Major Product: Chloromethane, essential for studying halogenation processes.

(iii) $C_3H_6 + CH_3Cl \rightarrow$

Equation: $C_3H_6 + CH_3Cl \rightarrow C_3H_5Cl + CH_4$ (Hydrochlorination)

Major Product: 1-Chloropropane, important for alkene addition reactions.

14. (c) Predict the major product formed during the hydrochlorination of propene (CH_3-CH=CH_2)

Reaction: CH_3-CH=CH_2 + HCl → CH_3-CHCl-CH_3 (Markovnikov addition)

Major Product: 2-Chloropropane, due to the addition of Cl to the more substituted carbon, critical for understanding alkene reactivity.

SECTION C (40 Marks)

Answer two (2) questions from this section.

15. (a) Answer the following questions in brief:

(i) Give one reason for rinsing apparatuses before putting the non-self indicator solutions is conducted

Rinsing removes impurities, like residual chemicals, ensuring accurate chemical reactions during titration.

(ii) State what will happen if titration with non-self indicator without indicator

The endpoint will not be visible, such as no color change, leading to inaccurate titration results.

(iii) Give an explanation why certain solutions are warmed during titration if more solvent is added

Warming increases solubility, like dissolving precipitates, ensuring a homogeneous solution for precise chemical titration.

(iv) State what will happen in a solution of a given concentration into it

Adding solvent dilutes the solution, like reducing molarity, affecting the chemical concentration and reaction rates.

(v) Why is a pilot not involved in calculating titre volume? Give one reason

A pilot titration estimates the endpoint, like an initial test, and is not precise enough for final chemical calculations.

15. (b) Suppose you are in-charge of Chemistry Laboratory, a 24 Hours Advance Instruction of CSEE Chemistry Practical directs you to prepare a 100 cm^3 per candidate of 0.1 M Na_2CO_3. Describe how you will go about preparing this solution for 25 candidates

Step 1: Calculate moles needed: 0.1 M × 100/1000 dm^3 = 0.01 moles per candidate; for 25 candidates, 0.01 × 25 = 0.25 moles.

Step 2: Molar mass of Na_2CO_3 = 106 g/mol; mass = 0.25 × 106 = 26.5 g.

Step 3: Dissolve 26.5 g of Na_2CO_3 in a small amount of distilled water in a beaker.

Step 4: Transfer the solution to a 2.5 dm^3 volumetric flask (25 × 100 cm^3 = 2500 cm^3).

Step 5: Add distilled water to the mark, mix thoroughly, ensuring a uniform 0.1 M Na_2CO_3 solution, essential for precise chemical preparation.

16. (a) State four characteristics of specific instructional objectives

Measurable: Objectives define outcomes, like calculating pH, allowing quantifiable chemical results.

Specific: Focus on precise goals, such as balancing equations, targeting clear chemical skills.

Achievable: Set realistic targets, like identifying gases, within practical chemical constraints.

Time-Bound: Include deadlines, such as completing a reaction in 40 minutes, ensuring timely chemical tasks.

16. (b) Explain six advantages of having instructional objectives

Guides Planning: Objectives, like mastering titration, direct lesson structure for chemical focus.

Clarifies Goals: Defines expectations, such as naming compounds, ensuring clear chemical targets.

Enhances Assessment: Provides criteria, like reaction rates, for evaluating chemical performance.

Improves Focus: Keeps activities on track, such as studying acids, avoiding irrelevant chemical topics.

Motivates Learners: Clear aims, like solving stoichiometry, encourage engagement in chemical tasks.

Ensures Consistency: Aligns lessons, such as on bonding, maintaining uniform chemical progression.

17. Explain six criteria for selecting the quality textbook for Chemistry subject

Accuracy: Ensures correct information, like precise pKa values, for reliable chemical knowledge.

Clarity: Uses simple language, such as explaining reactions, aiding chemical comprehension.

Relevance: Covers syllabus topics, like organic chemistry, aligning with chemical requirements.

Visual Aids: Includes diagrams, such as molecular structures, enhancing chemical understanding.

Practice Questions: Offers exercises, like balancing equations, supporting chemical skill development.

Current Content: Reflects recent advances, such as new catalysts, ensuring up-to-date chemical information.

18. (a) Briefly describe the levels of cognitive domain in increasing hierarchy

Knowledge: Recalling facts, like naming elements, forms the base of chemical understanding.

Comprehension: Understanding concepts, such as explaining reactions, builds on knowledge.

Application: Using knowledge, like solving pH problems, applies chemical principles.

Analysis: Breaking down information, such as analyzing spectra, deepens chemical insight.

Synthesis: Creating new ideas, like designing experiments, integrates chemical concepts.

Evaluation: Judging outcomes, such as assessing reaction efficiency, completes cognitive hierarchy.

18. (b) Explain briefly five suggestions for the construction of a good test

Clear Instructions: Provide precise directions, like "calculate moles," ensuring chemical task clarity.

Balanced Difficulty: Include varied questions, such as basic and advanced stoichiometry, testing diverse chemical skills.

Relevant Content: Align with topics, like reaction rates, matching chemical objectives.

Time Appropriateness: Allow sufficient time, such as 10 minutes per problem, for chemical problem-solving.

Objective Scoring: Use defined criteria, like correct pH values, ensuring fair chemical assessment.